

Pervasive Asthma Monitoring System



PAMS

A Health Systems Approach to Remote Monitoring of Asthma

TEAM FREE RADICALS

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Introduction

All medical ailments can be divided into being either acute (< 3 weeks) or chronic (> 3weeks). The term acute disease comprises of conditions like a sore throat or an episode of acute appendicitis. Common examples of chronic conditions are diabetes, asthma, heart failure and chronic obstructive pulmonary disease. Remote monitoring of chronic diseases is a new and exciting field in health care. The ultimate goal of this concept is to deliver healthcare to individuals irrespective of whether they are in a health care facility or not. In developing PAMS we have applied this concept to asthma – a disease caused by the temporary narrowing of the lung airways.

The Problem

Asthma is a chronic incurable disease which is known to present as exacerbations termed as asthma attacks. These asthma attacks can occur in all categories of asthma patients irrespective of whether they are on medication or not. Other than the fact that these attacks cause patients tremendous discomfort, and can potentially be fatal, each of these results in emergency room visits which cost nations millions of healthcare dollars. The only way to prevent these attacks is to monitor the asthma patients closely for any early signs of broncho-constriction; or narrowing of the lung tubes. When this is detected the patient's medication is changed accordingly to prevent a possible asthma attack.

There are two main problems with the existing system that is used to monitor asthma. The first problem is that in most cases asthma monitoring stops as the patient leaves the hospital. The second problem is that the current gold standard in home asthma monitoring – the peak flow meter is not a reliable method of predicting asthma attacks. Another problem that is common to this situation as well as other IT related health care solutions is that the existing system does not include both the patient and hospital end.

Our Solution

Our mission statement is *“to reduce the number of ED visits for asthma patients by integrating commonly available inexpensive devices in its monitoring”*. We propose the use of commonly available devices like mobile phones and portable mp3 players as sensors for asthma monitoring to augment the existing monitoring system. We realize that in order for this concept to be useful it needs to be comprehensive and thus PAMS include both the hospital and patient end. At the patient end PAMS facilitates the automatic transfer of information from existing monitoring devices, the spirometer and the peak flow meter to the

hospital interface. It also introduces two new devices the modified portable music player as a wheezometer and the mobile phone as an adverse effect monitor.

Process of Developing a Solution

We spent a lot of our time in the health systems classes in trying to clearly specify the problem. After three class presentations and voluminous discussions with the students and faculty we managed to convince ourselves and others that remote monitoring is a significant enough issue to be addressed. Following this we applied the user centered design process to the problem at hand:

1) Understanding the context	7) Basic system design and lay out
2) User analysis	8) Sketches and Mock ups
3) Environmental analysis	9) Interface analysis
4) Task analysis	10) Prototype
5) Function allocation	11) Discount usability testing
6) Existing system analysis	12) User evaluation

Review of Evidence and Related Work

During our analysis of the existing system we found evidence that can be categorized in to one of the following groups:

- 1) Monitoring of chronic diseases is as important as diagnosis and treatment
- 2) Tele monitoring of chronic diseases can reduce ED visits thus conserve national resources
- 3) The current gold standard in monitoring of asthma – Peak Flow Meter is not a sensitive or specific indicator of broncho-constriction.

We also found telemedicine applications that address this issue in pieces but each of them had some of the problems we mentioned above. We also visited the Dekalb County hospital to have a look at their cardiac telemetry and gained some valuable insight to the inpatient remote monitoring. It is our observation that many of the tele medicine systems aim to diagnose diseases remotely and ours is one of the very few that is applying this concept to remote monitoring. One of the components of PAMS – Digital Signal Processing is also a well researched topic but is not applied to remote monitoring of asthma as of now.

Telemedicine

The emphasis on telemedicine has been growing each year as hospitals try to reduce the number of visits to the hospital. The main focus is to reduce visits to save money and vital resources which include doctors, and nurses. Since our main focus has been on asthma here is some of the evidence that backs up telemedicine as a good measure to deal with asthma.

American Telemedicine Association

The ATA did a study in West Texas on seventeen school children that lasted for 24 weeks. The students were first given training by a school nurse on how to accurately use the devices that they were given for monitoring. At the end of the testing period, the children showed an 83% increase in symptom free days, a 44% reduction in daily symptom scores, and a 50% reduction in number of clinic visits.

Department of Pediatrics: Stanford University

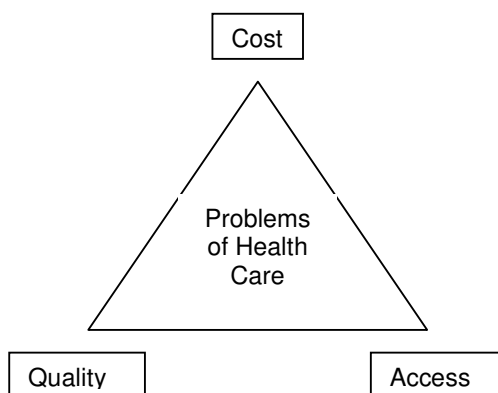
The study was conducted on school children. After the completion of the study, patients had shown a 40% reduction in asthma attacks, 26% reduced unscheduled acute care visits, 59% reduced ED visits, and an improvement in family social activities.

Japanese Department of Health

The Japanese Department of Health conducted a study to find out if telemedicine specifically geared toward asthma reduced the number of hospitalizations of patients. The telemedicine group was given training by a physician and they were given regular check ups at intervals of 4 weeks. The study showed a significant decrease of 55% in hospitalizations of the telemedicine group when compared to the control group. The study also revealed that telemedicine patients had a much better idea of their problem and showed greater awareness of symptoms for asthma than the control group. Finally the telemedicine group showed much better technique of taking readings than the control group.

Health Systems Perspective

The Pervasive Asthma Monitoring System is a novel concept which combines the existing time-tested methods of monitoring asthma such as peak flow meter and spirometry readings along with evidence based factors such as wheeze and adverse effects. From a health systems perspective, PAMS focuses on all the 3 factors and ensures a change in one factor does not increase the other. Each factor can be considered from the standpoints of each of the stakeholders:



1. Cost:

- Patient: The patient pays a nominal subscription fee to the telecom provider. The wheeze is measured using an inexpensive mp3 player which allows versatility. The benefits of this investment are - number of ED visit which a patient has to make for his asthma condition reduces thus resulting in a decrease in medical expenses. The continuous monitoring also results in lesser asthma attacks and avoids potential re-admissions.

2. Access:

- Physicians: The physician or nurse practitioner can monitor the conditions of several patients in much lesser time. PAMS allows asthma monitoring to reach out to those patients who live in rural areas or far away from the hospital premises.

3. Quality:

- Hospitals: Lesser ED visits allows hospitals to better deal with problems of overcrowding in the ED. Evidence indicates that using telemedicine, the ED visits can be reduced by as much as 40%. The continuous monitoring of patient symptoms improves the patient outcomes since the diagnosis is current, up-to-date and real-time, based on which the treatment plan is formulated.

Challenges Ahead

- Accuracy of recording: The wheezo-meter can pick up ambient noise and other signals which could distort the accuracy of wheeze recording.
- Motion: The ideal conditions for recording the wheeze would be when the patient is drawing deep breaths and the pendant is close to the thoracic region. Movement such as running or walking briskly, movement of clothes on the skin can distort the wheeze recording to a certain extent.
- Incompatibility: The different equipment used for monitoring the patient symptoms don't interact and are incompatible with each other. Different electronic equipment such as PEF meter, mobile phone and mp3 player implied different standards.
- Voice Analysis: The field of voice analysis is a vast subject and developing the software to perform the voice analysis within 3 months was a challenge.

Reflections

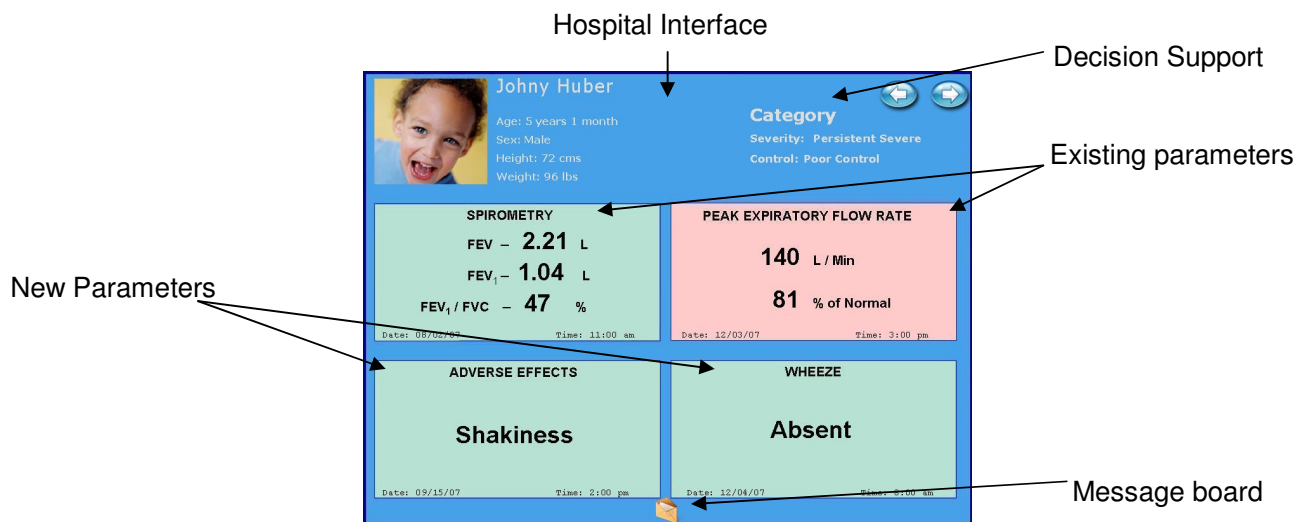
The remote monitoring of any chronic disease has tremendous potential in reducing the pain and misery of both the care receivers and the care givers in addition to saving healthcare resources for the nation. The existing systems tend to focus more on tele diagnosis as compared to tele monitoring. Any care giver would agree that diagnosis is as much of an art as it's a science as thus the physical presence of the patient is extremely important for it. Monitoring of chronic diseases on the other hand is a comparatively mechanical process and patients need not come to health care facilities everytime, especially not when they are healthy. Just like any successful solution this concept also requires a multidisciplinary effort. Our team consisted of members who had prior experience in health systems, electrical engineering, industrial engineering, human computer interaction and medicine. Even with these diverse back grounds we feel that

there is a need for other fields like information technology and management to handle the complete scope of PAMS.

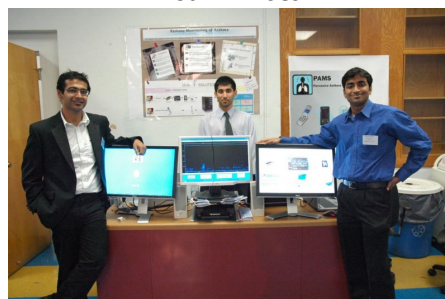
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Graphical Presentation



Team Photo



The "Wheezometer"



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